Dynamic Impacts of Rising Lumber Prices on Housing-Related Prices

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A monthly vector autoregression model of lumber, lumber futures, construction materials, housing, and shelter prices was shocked with a 10% lumber price increase, and dynamic responses were examined. Futures and materials price increases were immediate and endured 1 and 3 years, respectively. Housing and shelter price increases required at least 9 months to begin, and endured for about 3 years. Effects on materials, housing, and shelter prices were less than one-for-one. Price effects from a 10% future price increase imposed on the model were more delayed, weaker, and less enduring than those generated by lumber price shocks. © *1994 by John Wiley & Sons, Inc.**

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During the year ending March 1993, the producer price index (PPI) for lumber rose 34%, and the nearby futures price of lumber (hereafter futures price) rose more than twice that percentage (77%).[1,2] Between March and April 1993, the rate of lumber price increase dropped noticeably to 1.2%, while lumber futures price actually declined 19.6%.[1,2] Nonetheless, the April 1993 levels of these prices far exceeded levels of a year previous.[1,2] Reasons offered at this writing for the escalation include an enhanced lumber demand from the recovering economy's increased residential

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construction; a reduction in timber supplies from Pacific Northwest forests because of legal and environmental concerns; and perhaps some speculative buying.[3] Whatever the cause, the price increases and greater price volatility over the year ending in April 1993 should influence lumber-related prices in the construction and housing sectors of the economy.

The focus of this paper is to use data-oriented statistical methods to ascertain how much, and with what dynamic patterns, related construction and housing prices should react to shocks in the lumber and lumber futures prices. This article uses vector autoregression (VAR) methods to map the historical dynamic effects of

1. A one-time 10% rise in the lumber price on the futures price, the price of construction materials, the consumer price of housing, and the consumer price of shelter (hereafter called the *lumber price experiment*); and,
2. A one-time 10% rise in the lumber futures price on the lumber price, the price of construction materials, the consumer price of housing, and the consumer price of shelter (hereafter called the *futures price experiment*).

Specifically, we set out to answer the following six questions concerning how shocks in lumber and in lumber futures prices dynamically affect the remaining four respondent prices in each experiment: (a) What are the reaction times required for the prices to begin responding to each shock? (b) What dynamic patterns do the monthly responses take? (c) To what degree do the prices ultimately respond to each shock? (d) What are the duration times required for prices to completely respond? (e) What are the strengths of relationships among the five prices? (f) What are the differences in (a) through (e) elicited by a shock in lumber price as opposed to a shock in lumber futures price? Questions related to (f) include whether futures price responds more to lumber price than lumber price responds to futures price, and whether lumber price shocks elicit more pronounced housing-related price effects than shocks in futures price.

Methods, Model, and Data

Common sense, observed history, and economic theory suggest that large increases in the price of such a major construction/housing input as lumber should elicit increases in the prices of related lumber, construction materials, and housing/shelter prices. The results presented below confirm that such effects do occur. Yet what is not evident from common sense, observed history, or economic theory, and what is provided by our results, are the dynamics with which such price effects occur. That is, answering the six questions listed above implies focusing not so much on *if* respondent prices react in each experiment, as on *how* the prices react. Static economic theory and conventional econometric models that intensively use static economic theory are equipped to handle questions concerning what happens at the static equilibria before and after the shock.[4,5] "Structural" econometric models often have little to say about what occurs dynamically between equilibria.[4] In other words, structural econometric models and static economic theory cannot fully answer the above six dynamic questions about each experiment's respondent prices.[4,5] Dynamic timing (reaction and duration times), distribution of monthly effects, and ultimate response levels certainly have policy implications, as explained below. Vector autoregression (VAR) econometric methods better handle these dynamic inter-equilibria issues because the technique is data oriented and imposes as few *a priori* theoretical restrictions as possible, so as to allow the dynamic regularities in the time-ordered data to reveal themselves.[4,5,*] The literature is replete with detailed summaries and derivations of VAR methods. For such summaries, one should consult Sims,[12] Bessler,[4,5] and VanTassell and Bessler.[13]

Our five-equation VAR model takes the following form:

$$\begin{aligned} x_t = a_{0,x} &+ a_{x,T}\text{*TREND} \\ &+ a_{x,1}\text{*LUMBER}_{t-1} + \ldots \\ &\quad + a_{x,10}\text{*LUMBER}_{t-10} \\ &+ a_{x,11}\text{*FUTURES}_{t-1} + \ldots \\ &\quad + a_{x,20}\text{*FUTURES}_{t-10} \\ &+ a_{x,21}\text{*MATLS}_{t-1} + \ldots \\ &\quad + a_{x,30}\text{*MATLS}_{t-10} \\ &+ a_{x,31}\text{*HSG}_{t-1} + \ldots\ldots. \\ &\quad + a_{x,40}\text{*HSG}_{t-10} \\ &+ a_{x,41}\text{*SHELT}_{t-1} + \ldots.. \\ &\quad + a_{x,50}\text{*SHELT}_{t-10} + R_{x,t} \end{aligned} \tag{1}$$

The subscript t denotes the current value, whereas subscript $(t - i)$ refers to the ith lag from period t's value. The upper-cased subscript T represents the coefficient on time trend or TREND. On the left hand side, x = LUMBER, FUTURES, MATLS, HSG, and SHELT. The latter variable labels reflect, respectively, the prices of lumber, lumber futures, construction materials, consumer housing, and consumer shelter. The coefficient with a nought subscript represents the intercept. $R_{x,t}$ represents white noise residuals.

Monthly producer and consumer price indices (PPIs, CPIs) obtained from the US Bureau of Labor Statistics (BLS) served as price series for all but the lumber futures price.[1,14] The BLS PPI for lumber serves as lumber price (LUMBER).[1] The wholesale price of construction materials (MATLS) is represented by the PPI for construction materials.[1] The CPI of all urban consumers for housing services represents the consumer price of residential housing services (HSG).[14] What was desired was a broader price than that of newly built home-owned residential units. The CPI for housing includes prices of owned and rented shelter services, as well as prices of upkeep, household expenses, and furnishings, that are to varying degrees, lumber-dependent. The CPI of all urban consumers for shelter (SHELT) is a more narrowly defined price than the housing CPI.[14,†] The CPI for shelter

*When individually nonstationary variables move in a tandem and stationary long run path as a system, the variables are said to be cointegrated.[6] With more than two cointegrated variables, one should use the maximum likelihood vector error-correction (VEC) methods developed by Johansen[7] and Johansen and Juselius.[8] But cointegration and the appropriateness of the VEC methods are not issues here because the five prices are each individually stationary. Dickey–Fuller tests conducted on each price's logged levels generated pseudo-τ_μ values that ranged from −6.9 to −3.4 (see refs. 9 and 10 for test procedures). Because all τ_μ values were negative and of absolute values above 2.89, evidence at the 5% significance level was sufficient to reject the null hypotheses that each price is nonstationary. Since the prices form a stationary system in nondifferenced logged levels, a vector autoregression in logged levels is appropriate.[11]

†In January 1984, the CPIs for housing and shelter were redefined. Henderson[15] and Campbell[16] note that the indexes were redefined to reflect housing and shelter in terms of rental service equivalence, that is what a unit could be rented for, rather than what the unit costs and what it is worth as an investment. If possible, we wanted to avoid using a shorter sample starting in 1984, as problems with small samples may well have arisen. We decided to test for structural change, and if evidence suggested that the redefinitions resulted in time variance of parameters over the sample, then we would use the shorter sample. We applied the data-analytic methods of CUSUM and CUSUMSQ plots described in Harvey[17] on the recursive re-

reflects the consumer price of rented and owned residential shelter.

The lumber futures price used is the closing price of the nearby futures contract (that contract nearest to expiration). However, to avoid potential problems associated with contract delivery, we did not use the nearby contract during its delivery month (the last month). If the nearby contract was into its last month, then the next nearby contract was used. To stay consistent with the timing of the BLS index data, we used the closing price on the Tuesday of the week containing the 13th of that month.[2,15]

Following VanTassell and Bessler[13] and Bessler,[4,5] the VAR model's lag structure was chosen using Tiao and Box's[18] likelihood ratio test procedure. Results (not reported here) suggest a 10-order lag. Each equation includes a constant, a time trend to account for time-dependent influences not of direct interest to this study, and a series of 11 centered indicator variables to account for seasonal influences. Monthly data for all five prices were available from January 1974 to December 1992. The 24 observations of the January 1974 through December 1975 subperiod were set aside for the Tiao–Box lag search, and the model in Eq. (1) was estimated over the January 1976 through December 1992 period. Data were transformed into natural logarithms, such that shocks to, and impulse responses in, the logged indices are proportional changes in the nonlogged prices. When multiplied by 100, the impulses approximate percent changes in the nonlogged prices.

The five VAR equations may have contemporaneously correlated innovations. Failure to correct for contemporaneously correlated current errors will produce impulse responses not representative of historical patterns.[12] A Choleski decomposition was imposed on the VAR for each experiment to orthogonalize the current innovation matrix, such that the variance/covariance matrix was identity in each experiment. The Choleski decompositions resolve the problem of contemporaneous feedback.

Each decomposition requires an arbitrary imposition of a Wold causal ordering among the current values of the dependent variables.[4,5] In the lumber price experiment, the chosen ordering was LUMBER, FUTURES, MATLS, HSG, and SHELT. The chosen ordering in the futures price experiment was the same except that the ordering of the lumber and lumber futures prices was reversed. The choices of these orderings were based on a number of considerations. First, common sense, observed history, and economic theory all suggest that there is a valid line of causality from lumber and lumber futures price movements to the lumber-dependent prices of construction materials, housing, and shelter. Second, futures and lumber prices tend to move tandemly. Third, Sims[12] and Bessler[4,5] suggest that when there is a valid line of causality, as there is from lumber and lumber futures prices to the other prices, then the variable shocked is placed atop the ordering. Fourth, the bottom three prices in each experiment were ordered as MATLS, HSG, and SHELT. Lumber is a residential housing input. Consequently, a shock in lumber or futures price could first influence construction materials price, sug-

siduals of each of the five VAR equations. Fortunately, evidence at the 1% significance level was *insufficient* to reject the null hypothesis of parameter time invariance for each equation. Consequently, we considered the entire sample beginning in January 1974, and for reasons cited below, estimated over the January 1976 through December 1992 period.

gesting that materials price be placed third in each ordering.

A Ljung–Box portmanteau value, calculated for an equation's residuals, tests the null hypothesis that the equation has been adequately specified (see Harvey[17] and Granger and Newbold[19]). The five Ljung–Box values range from 32.8 to 46.4, and are less than the critical chi-square value of 66.2 at the 1% significance level. Thus, evidence is insufficient to reject the null hypothesis of adequate model specification.

Stationarity of the estimated equations is required. We therefore tested for the stationarity of the innovations or residuals of each VAR equation using augmented Dickey–Fuller (ADF) tests. The null hypothesis of nonstationarity was rejected in both the τ_μ and τ_τ ADF tests because the t-like values on the nondifferenced regressor were negative and had absolute values that exceeded 3.5 for the τ_μ test and 4.04 for the τ_τ test.[10] The five ADF t-like values ranged from about -10.1 to -9.5 for the both the τ_μ and τ_τ tests.[9,10] As expected with a VAR model of five individually stationary prices, each VAR equation appears stationary. The combined Ljung–Box and ADF results suggest that each equation of the VAR model has been adequately specified.

Impulse Responses in Related Prices to Shocks in Lumber and Futures Prices

The impulse response function simulates, over time, the effect of a one-time shock in one of a VAR's series on itself and on other series in the system.[4,5] Increases of 10% were chosen because one does not currently know at this writing to what point lumber and lumber futures prices will ultimately climb (or recede for that matter). A 10% shock is conveniently sized because of the VAR model's linearity. That is, the shapes of both experiments' impulse patterns in Figures 1 and 2 would remain the same, with only the scales of the vertical axes varying with differently sized shocks.[‡]

The impulse responses are reported for the lumber price experiment in Figure 1 and for the futures price experiment in Figure 2. Dynamic aspects obtained from the impulse response results are summarized in Table I. These results reflect price patterns averaged over all of the sample's interactions, and are indications of how history's average dynamic patterns would have "handled" the shocks of the size imposed on the model. The results reflecting such average historical dynamics are valid in characterizing the current recent rises in lumber and lumber futures prices insofar as current conditions are similar to history's average conditions captured by the model.

Impulse responses are approximate changes in the nonlogged prices, and are not price levels. Kloek and Van Dijk's[20] Monte Carlo methods generated t-values for each impulse response. These values test the null hypothesis that each impulse is zero-valued. Most of the plotted impulse responses are statistically nonzero at the 5% significance level.[§]

‡For example, one can, by the model's linearity, characterize the impulse response simulations to 20% shocks by simply multiplying the impulses from the 10% shock experiments by a scaler of 2.0.

§Within the "interior" of sequences of significant impulses, there are a small number of impulses that failed to achieve statistical significance at the 5% level. Given scaling problems and similar magnitudes of some of the materials, housing, and shelter price impulses, we were not able to distinguish this very small number of insignificant impulses with markers without rendering the plots very unclear. The scaling problems are evident from Figure 1, where the vertical scale extends over a wider range than Figure 2. Shelter price im-

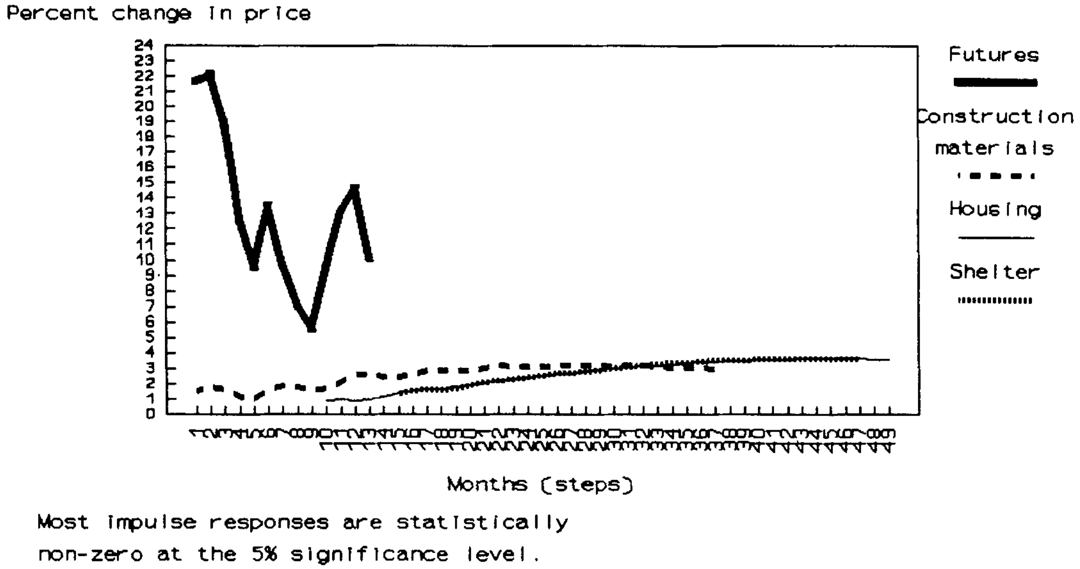

Figure 1. Impulse Responses in Lumber Futures and Housing-Related Prices from a 10% Increase in Lumber Price.

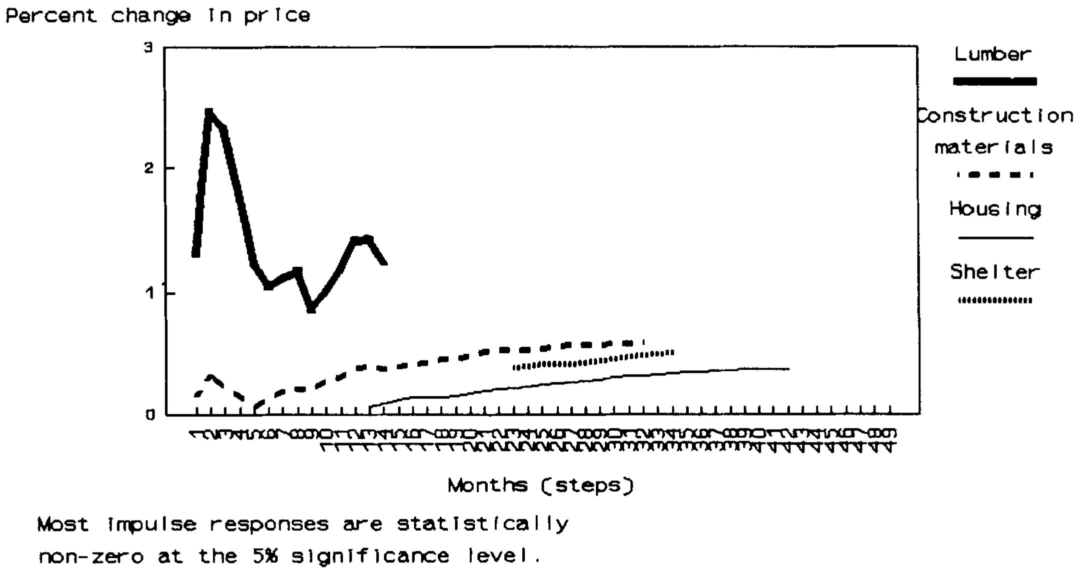

Figure 2. Impulse Responses in Lumber and Housing-Related Prices from a 10% Increase in Lumber Futures Price.

pulses in Figure 1 appear equal to housing impulses, when, in fact, most of these shelter price impulses in this range of apparent impulse equality slightly exceed the housing impulses. The nonequality of concurrent shelter and housing price impulses actually resembles the patterns of Figure 2, where inequality is evident because Figure 2's range of vertical axis values is far less than that of Figure 1.

Table I. Dynamic Aspects of Price Response Patterns of the Lumber and Futures Price Experiments.

Dynamic Aspect	Lumber Price	Futures Price	Materials Price	Housing Price	Shelter Price
Reaction times (months)					
Lumber price exp.	—	0	0	9	14
Futures price exp.	0	—	0	12	22
Response directions					
Lumber price exp.	—	Rise	Rise	Rise	Rise
Futures price exp.	Rise	—	Rise	Rise	Rise
Response patterns					
Lumber price exp.	—	Sharp, then decay	Shallow, then accelerate	Shallow, then accelerate	Shallow, then accelerate
Futures price exp.	Sharp, then decay	—	Shallow, then accelerate	Shallow, then accelerate	Shallow, then accelerate
Response durations (months)					
Lumber price exp.	—	13	37	40	33
Futures price exp.	14	—	32	30	12
Multipliers					
Lumber price exp.	—	1.6	0.48	0.54	0.48
Futures price exp.	0.38	—	0.22	0.24	0.10

Impulse Responses: The Lumber Price Experiment

Reaction times required for futures, materials, housing, and shelter prices to respond to lumber price shocks vary. Perhaps because of its speculative and anticipatory nature, the futures price begins reacting during the same month as (within 29 days of) the lumber price movement. And, perhaps because of the short times required for construction materials to be manufactured, and for stored inventories to be repriced, construction materials prices also start responding during the same month as the shock. Reaction times for the remaining prices are longer: 9 months for housing price and 14 months for shelter price. Babula, Gajewski, and Colling[21] note that reaction times of 9–14 months may reflect the lags inherent in planning, constructing, and marketing (selling or renting) residential units. In addition to shelter price, housing price includes such other housing-related prices as furnishings and upkeep service prices that may be lumber dependent, and that may respond to lumber shocks sooner than shelter prices.[21] Hence, the housing price's reaction time is less than that required of the shelter price's responses.

Generally, changes in lumber price have historically elicited similarly directioned movements in futures, materials, housing, and shelter prices. Although there may be event-specific examples in the past where this is not true, the model suggests that lumber price and the other prices move along generally tandem paths.

The impulse patterns of the materials, housing, and shelter prices have been more enduring than those of futures price. Futures price responds rapidly, sharply, and then takes on a gradually decaying pattern, while lasting just over a year. This is consistent with media reports of sharply escalating and volatile lumber futures prices.[22] The impulse response patterns of the materials, housing, and shelter prices differ from futures price impulses in being generally more muted in magnitude, in lasting longer periods of time, and in taking on patterns where responses gradually accelerate over the response period. These initially shallow patterns begin at very low magnitudes and then accelerate in strength. However, they are still muted when compared in magnitude to the futures price impulses. The impulses endure from month 1 through month 37 or about 3 years for materials price; from month 10 through month 49 or just over 3 years for housing price; and from month 15 through month 47, or almost 3 years, for shelter price. The results are consistent with the notion that time is required for shocks in lumber prices to "filter down" to related construction and housing prices at the producer and consumer levels. Futures contracts are commitments to deliver at a specified price on some future date. Actively traded each day, a futures price can react to new information, new public sentiments or perceptions, changing market supply and demand conditions, and to political developments (such as the imposition or relaxation of injunctions against harvesting lumber in certain areas) than can the materials, housing, and shelter prices. The latter three prices, especially shelter and housing prices, have response durations and reaction times governed by contracts into the future, lengthy production lags, and often protracted marketing lags before final prices can be consummated.[21] The shorter reaction times and response durations of futures price are therefore not surprising.

Babula and Bessler[23] present a method of calculating price response multipliers. The multipliers of price response to lumber price shocks in Table I suggest the respondent price's average historical percentage reaction to each percent change in the shock variable.‖ The multipliers are positive, suggesting that movements in lumber price elicit price responses in the same direction as the shock. The futures price's multiplier for the lumber price experiment is 1.6 suggesting that each 10-point rise (fall) in lumber price elicits, on average, a larger 16% rise (fall) in futures price over a 13-month period.¶

‖By a VAR model's definition, each variable is posited as a function of a specified number, here 10, lags of each endogenously modeled variable in the system. Hence a one-time shock to the system places all five variables into cycles of monthly pulsation, including the shock variable. Insofar as the data levels are modeled in natural logarithms, then shocks to, and impulse responses in, the logged variables constitute proportional changes in the nonlogged variables, and percent changes in the nonlogged variables when multiplied by 100. As an example, consider the materials price's multiplier from the lumber price experiment. First, one adds up the 37 statistically nonzero materials price impulses to obtain a cumulative percent change in MATLS response. Second, one sums the corresponding shock variable impulses into a cumulative change in lumber price. Finally, one divides the percent change of the shock variable into the percent change in the response variable to obtain, here, the materials price's multiplier of percentage point response to a point change in lumber price. These are history's average responses. One calculates such an elasticity for the four respondent prices in each of the two experiments.

¶The PPI for lumber is an index of a number of lumber product prices at many pricing points, whereas the futures price is for a certain grade of lumber at one point. Yet the futures price can serve, and has often served, as a representative price for a wider array of lumber products. Therefore, we cannot conclude that the futures price response is 1.6 times the "lumber" price response. However, the results of Figures 1 and 2 and Table 1 do indicate that futures price tends to react with greater force than other modeled prices in the short-term. This is particularly evident from the futures price impulses of Figure 1.

Likewise, each 10% increase in lumber price elicits over periods ranging from 33 to 40 months, increases of 4.8% in materials price; 5.4% in housing price; and 4.8% in shelter price. Therefore, the effects of the lumber price shock have been less than one-for-one on all prices except futures price.

Impulse Responses: The Futures Price Experiment

The dynamic aspects with which lumber, materials, housing, and shelter prices respond historically to futures price shocks are reported in Table 1 and Figure 2. Lumber and materials prices begin reacting during the same month as the futures price shock. The housing and shelter prices require from 12 to 22 months before reacting to the futures price shock. Generally, lumber futures price and the four other prices have historically moved in similar directions.

Positive futures price shocks elicit lumber price increases that are pronounced early in the response cycle, and that decay through the remainder of the 14-month cycle. For reasons mentioned above, the impulse responses of the materials, housing, and shelter prices differ from those of lumber price in being generally weaker in magnitude, in lasting for longer periods of time, and in taking on patterns that gradually accelerate, rather than sharply decay, over the response cycle. Materials price responses begin in month 1 and last for 32 months. Housing price impulses endure for a 30-month period beginning in month 13. Shelter price responses continue for 12 months after requiring nearly 2 years (22 months) to begin. The more muted and protracted responses in materials, housing, and shelter prices reflect the time lags required to plan, build, and market residential units.[21]

Multipliers for the futures price experiment are reported in Table I. The multipliers suggest that responses to futures price movements have been less than one-for-one. A 10% increase elicits an increase of 3.8% in lumber price over a 14-month period; an increase of 2.2% in materials price over a 32-month period; an increase of 2.4% in housing price over a 30-month period; and an increase of 1% in shelter price over a 12-month period.

Strength of Price Relationships: Analyses of Forecast Error Variance Decompositions

Analysis of decompositions of forecast error variance (FEV) is another tool of VAR econometrics for discerning relationships among the modeled system's time series. FEV is, at alternative horizons or steps, attributed to shocks in each of the system's series, such that a measurement of relative "strength" of relationships emerges.[4,5] According to Bessler,[4] FEV decompositions provide a generalized framework to analyze in-sample Granger causality relationships among the modeled variables. Error decompositions attribute within-sample variance to alternative series and thus give measures that are useful in applied work. In Table II, the top portion contains the FEV decompositions of the lumber price experiment, and the bottom portion contains the FEV decompositions of the futures price experiment.

Recall that the lumber price experiment was conducted under the following causal ordering: lum-

Table II. Decompositions of Forecast Error Variance (FEV) for the Lumber and Futures Price Experiments.

		Percent Explanation of Forecast Error Variance from				
Variable	Step	Lumber Price	Futures Price	Materials Price	Housing Price	Shelter Price
FEV Results from the Lumber Price Experiment						
Lumber Price						
	1	95.36	3.96	0.03	0.23	0.42
	3	84.88	6.06	4.64	4.10	0.31
	6	70.37	4.49	10.19	12.26	2.69
	12	65.08	3.62	11.32	16.09	3.88
	18	58.79	3.35	20.53	13.17	4.15
	24	53.30	3.39	28.38	10.67	4.26
	30	47.20	3.63	35.21	9.47	4.48
	36	42.78	3.92	39.04	9.42	4.83
Futures Price						
	1	35.35	64.17	0.12	0.03	0.33
	3	35.22	54.26	5.88	4.33	0.31
	6	34.49	47.51	10.66	6.77	0.57
	12	37.04	38.83	13.61	9.77	0.76
	18	36.13	36.49	15.94	10.64	0.80
	24	35.67	35.09	18.21	10.25	0.78
	30	34.51	33.93	20.59	10.09	0.88
	36	33.59	32.91	22.05	10.26	1.19
Materials Price						
	1	42.65	1.35	55.26	0.71	0.03
	3	39.24	0.73	52.25	7.52	0.26
	6	42.45	1.20	42.24	13.01	1.09
	12	53.67	0.85	24.59	20.22	0.67
	18	65.05	1.04	16.07	17.20	0.64
	24	69.00	1.59	16.36	12.17	0.88
	30	67.41	2.16	20.99	8.45	1.00
	36	63.59	2.64	26.57	6.29	0.91
Housing Price						
	1	0.10	0.18	0.09	99.16	0.47
	3	0.29	0.21	0.09	97.95	1.47
	6	0.72	1.39	0.44	95.52	1.93
	12	9.68	2.82	0.55	82.63	4.32
	18	27.67	5.50	1.10	58.59	7.13
	24	46.15	5.71	0.92	37.81	9.41
	30	58.23	4.82	0.91	25.73	10.30
	36	64.84	3.97	2.78	18.42	9.99
Shelter Price						
	1	0.23	0.24	0.19	74.61	24.73
	3	0.51	0.16	0.37	73.79	25.17
	6	0.66	1.88	1.42	69.45	26.59
	12	5.30	2.10	1.60	57.03	33.97
	18	16.04	2.64	2.77	41.75	36.81
	24	30.04	2.35	2.79	30.28	34.54
	30	42.78	1.94	2.12	23.33	29.83
	36	52.14	1.66	3.44	18.21	24.55

Table II. (*Continued*)

Variable	Step	Lumber Price	Futures Price	Materials Price	Housing Price	Shelter Price
		Percent Explanation of Forecast Error Variance from				
FEV Results from the Futures Price Experiment						
Lumber Price						
	1	54.95	44.37	0.03	0.23	0.42
	3	44.01	46.93	4.64	4.10	0.31
	6	37.01	37.84	10.19	12.26	2.69
	12	34.83	33.87	11.32	16.09	3.88
	18	31.13	31.01	20.53	13.17	4.15
	24	27.68	29.01	28.38	10.67	4.26
	30	23.97	26.86	35.21	9.47	4.48
	36	21.46	25.24	39.04	9.42	4.83
Futures Price						
	1	1.21	98.31	0.12	0.03	0.33
	3	1.89	87.58	5.88	4.33	0.31
	6	2.71	79.28	10.66	6.77	0.57
	12	6.48	69.39	13.61	9.77	0.76
	18	6.78	65.84	15.94	10.64	0.80
	24	7.12	63.64	18.21	10.25	0.78
	30	6.90	61.54	20.59	10.09	0.88
	36	6.83	59.67	22.05	10.26	1.19
Materials Price						
	1	29.37	14.63	55.26	0.71	0.03
	3	27.12	12.85	52.25	7.52	0.26
	6	33.11	10.54	42.24	13.01	1.09
	12	37.71	16.82	24.59	20.22	0.67
	18	42.46	23.62	16.07	17.20	0.64
	24	42.37	28.23	16.36	12.17	0.88
	30	39.49	30.08	20.99	8.45	1.00
	36	35.86	30.37	26.57	6.29	0.91
Housing Price						
	1	0.00	0.28	0.09	99.16	0.47
	3	0.06	0.44	0.09	97.95	1.47
	6	0.08	2.03	0.44	95.52	1.93
	12	3.50	8.99	0.55	82.63	4.32
	18	10.57	22.60	1.10	58.59	7.13
	24	20.51	31.35	0.92	37.81	9.41
	30	28.65	34.41	0.91	25.73	10.30
	36	33.83	34.98	2.78	18.42	9.99
Shelter Price						
	1	0.07	0.40	0.19	74.61	24.73
	3	0.31	0.36	0.37	73.79	25.17
	6	0.29	2.25	1.42	69.45	26.59
	12	2.09	5.31	1.60	57.03	33.97
	18	7.21	11.46	2.77	41.75	36.81
	24	15.82	16.57	2.79	30.28	34.54
	30	24.42	20.29	2.12	23.33	29.83
	36	30.72	23.08	3.44	18.21	24.55

ber price, futures price, materials price, housing price, and shelter price. The ordering for the futures experiment was the latter one with positions of lumber and futures prices reversed. Ordering influences the results, but perhaps not to as great an extent as is sometimes thought. Certainly, the materials, housing, and shelter prices, being lumber related, are plausibly situated at the bottom of the orderings of the lumber and futures price experiments. FEV decompositions for these three variables, the subordering of which is constant across experiments, take on the same patterns of FEV decompositions in both experiments. One can verify this by simply comparing FEV decompositions down one of these prices' columns across experiments. Further, the *combined* contributions of lumber and futures prices to explaining FEV decompositions take on the same patterns across experiments. For example, the combined explanation of materials price FEV from futures and lumber prices at month 24 is about 71% in both experiments. What differs across experiments is the breakdown of the combined FEV decompositions for these two prices. Hence, the degree to which lumber or futures price explains uncertainty in the other prices depends on the ordering, that is on which of the two prices is placed causally first in the ordering.

Lumber price is highly exogenous in the lumber price experiment, especially at horizons of 18 months or less, with 59–95% of lumber price's FEV self-attributed. This percentage ultimately drops below half and lumber price becomes increasingly endogenous. After the 18-month point, materials price takes on increasing importance in explaining up to 39% of lumber price FEV. These FEV results coincide with the impulse response results: price effects from lumber price shocks have required more than 2 years before running their complete course.

Lumber price is more endogenous in the futures price experiment than in the lumber price experiment. The lumber price FEV has been from 21.5 to 55% self-attributed, and from 25 to 47% attributed to futures price variation in the futures price experiment. This coincides with the futures price shock having elicited statistically nonzero impulse responses in lumber price.

Futures price is increasingly endogenous in the lumber price experiment beyond the 3-month horizon, when less than half of its FEV is self attributed. From 34 to 37% of futures price FEV is attributed to the lumber price. Futures price is more exogenous in the futures price experiment, where no less than 60% of its FEV is self attributed.

Whether lumber price affects futures price or futures price affects lumber price depends on which of the two prices is placed causally first in the ordering as the shock variable. Each shock variable exhibits high degrees of exogeneity and explains comparable FEV proportions of each other in the two experiments. So across experiments, the patterns with which lumber price accounts for futures price variability is similar to the patterns with which futures price accounts for lumber price variability. However, considering these FEV results with the two experiments' impulse response results adds further insight. Whereas lumber and futures prices explain similar percentages of each other's FEV across experiments, the impulse responses suggest that the sizes of effects explained vary noticeably across experiments. Compared with the futures price experiment, lumber price accounts for similar percentages of price effects that are larger.

Materials price's FEV becomes increasingly dependent on the combined variation of lumber and futures price after the 1-year horizon, when no less than 66% of materials price FEV is attributed to variation in lumber and futures prices. This generally coincides with the materials price impulses (Figs. 1 and 2) which require approximately 12–18 months to approach near-peak strength levels before levelling off.

Housing price is highly exogenous early on, with no less than 59% of its FEV being self-attributed through the 18-month horizon. Thereafter, the combined variation of lumber and futures prices accounts for most (52–69%) of housing price's FEV. These results reinforce the housing price impulse responses which take from 9 to 12 months to activate, and from 2.5 to 3 years after the shock to approach peak strength (Figs. 1 and 2).

Shelter price remains highly endogenous in both experiments, with from 25 to 37% of its FEV being self attributed at all reported horizons. Housing price variation is the major determinant of shelter price FEV at most of the reported horizons.

Comparative Dynamics of the Lumber and Futures Price Experiments

Compared with a futures price increase, a 10% rise in lumber price elicits price increases that form similarly shaped patterns, but that engage more rapidly; endure for longer periods; and achieve generally greater magnitudes. This is evident from Table I. When reaction times for a price across experiments differ, those of the lumber price experiment are shorter. A lumber price shock's effects generally endure for longer periods than do effects elicited by a futures price shock (see Table I, response durations). Figures 1 and 2 reveal, however, that the impulses of the two experiments take on similar monthly patterns—reaction times and durations notwithstanding.

The most evident difference in the price effects from shocks in lumber and futures prices is effect magnitude. Differences are apparent from comparing the scales of Figures 1 and 2, and from Table I's response multipliers. Lumber and futures price movements elicit statistically significant responses in each other, as well as in materials, shelter, and housing prices. Yet a lumber price shock elicits far greater impulse magnitudes than would an equally sized shock in futures price.

Another interesting comparison involves futures price responses to lumber price shocks as opposed to lumber price responses to futures price shocks. Figures 1 and 2 reveal that lumber and futures prices respond to each other with similar shapes and for comparable periods. Yet Figures 1 and 2, as well as Table I's multipliers, suggest that futures price reacts with noticeable volatility to lumber price. The multipliers suggest that percentage futures price response to lumber price is four times the percentage lumber price response to futures price. The relatively larger response in futures price may arise because lumber futures price more easily and markedly reacts to changing perceptions and market conditions, whereas lumber price's movements are guided, perhaps encumbered, by the production lags, planning periods, and marketing time requirements of the housing units for which lumber is an input.[21]

There are similarities and dissimilarities in FEV decomposition patterns across experimental orderings. The percentages of FEV of all prices attributed to variations in the three prices not repositioned by the experimental orderings—materials, housing, and shelter prices—are equal across experiments. The combined influence of lumber and futures price uncertainty on the FEVs of the system is the same across experiments, although the distribution of this combined influence on the prices' FEVs varies according to which of the two prices is placed first in the ordering and engages the system's shock. The lumber price percentage of this combined influence is greatest in the lumber price experiment, whereas the futures price's percentage is greatest in the futures price experiment. Although FEV decompositions suggest similar patterns of explanations across experiments, the impulse response results indicate that price effects are larger in the lumber price experiment.

Summary and Conclusions

The average monthly dynamic patterns captured by a vector autogregression model characterize what may happen to construction- and housing-related prices from the sharp increases in the size and volatility of lumber and lumber futures price movements during late 1992 and early 1993. Lumber price increases should elicit materials price increases that begin within a month, gradually accelerate over about a year before peaking in magnitude, and endure for about 3 years. Response should be less than one-for-one, with materials price rising by about half of the percent increase in lumber price over this period. An increase in futures price should influence materials price similarly, but by less and for shorter periods of time.

Some time (up to 14 months) would elapse before lumber price increases noticeably influence housing and shelter prices. Patterns of housing and shelter price increases would begin at low levels and then gradually gain strength. These price effects would be felt by housing consumers persistently and at low magnitudes for at least 2.5 years. Responses would be less than one-for-one, with housing and shelter price rising by about half of the percentage increase in lumber price. Housing and shelter price increases from rises in futures price would be more delayed, weaker, and shorter-lived than would those elicited by lumber price movements.

Futures price responds to a far greater degree to lumber price than lumber price responds to futures price. Each percent rise in lumber price elicits a greater 1.6% increase in futures price over about a year, whereas lumber price responds by about a quarter of that percentage to similar increases in futures price.

Increases in futures price elicit responses in construction and housing related prices that are often more delayed, weaker in strength, and less enduring than similar movements in lumber price. So to elicit given changes in materials, housing, and shelter prices, futures price would have to swing farther and wider than lumber price.

Were policy makers concerned about, for example, large and lasting lumber price and lumber futures price increases, a number of policy-relevant points emerge from these results. First, lumber price movements are more important than futures price movements to individuals concerned with effects on construction and consumer housing prices. While both prices elicit statistically nonzero responses, a given percentage response in materials, housing, and shelter prices requires a far greater percentage change in futures price than in lumber price. Second, policy makers have a noticeable period of time—from 9 to 22 months—to devise policies to counter a lumber or futures price shock's housing and shelter price effects before the onset of these effects. Third, potential policies should reflect that lumber and futures prices shocks elicit less than one-for-one responses (futures price response excepted). Fourth, if policy makers should delay in policy formulation, our results suggest that, once price effects begin, there is a notable time frame—from 2.5 to 3 years in some cases—for policy makers to introduce policy legislation before the effect cycle on consumer housing and shelter prices is finished. And fifth, there are policy-relevant timing issues that emerge from the results. Policies aimed at consumers of raw lumber should reflect that much of the lumber and futures price effects occur within the first half of an approximately year-long cycle. Policies geared toward consumers of housing and shelter services should reflect that much of the ultimate housing and shelter price effects occurs later in the multiyear cycle.

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